ETIOLOGY OF BACTERIAL SPOT OF STONE FRUITS WITH SPECIAL REFERENCE TO EPIPHYTOTICS AND TO DISSEMINATION OF THE CAUSAL ORGANISM (PHYTOMONAS PRUNI (E.F.S.) BERGEY ET AL.).

HOWARD WILLIAM LARSH
A.B., McKendree College, 1936
M.S., University of Illinois, 1938

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Introduction

Bacterial spot of stone fruits, caused by *Phytomonas pruni* (E. F. Smith) Bergey et al., was first described as a serious disease of Japanese plum in Michigan. Since the original description of the pathogen it has also been reported as causing disease of apricots, nectarines, and peaches. From the standpoint of fruit growers and plant pathologists this organism is of importance: first, because of the serious effects on the tree; secondly, because no successful means of control has been found.

In most instances the factors which influence the severity of bacterial spot of stone fruits remain doubtful, notwithstanding numerous researches. Although numerous explanations have been offered, the mode of overwintering, probably the most important factor in the life cycle of the organism from the standpoint of control measures, remained obscure when this study was begun.

Primarily because of insufficient knowledge of the behavior of *P. pruni* in Illinois this investigation was undertaken with the anticipation of securing data on the mode of overwintering, the dissemination of the causal organism, and the factors which influence the outbreaks of epiphytotics of bacterial spot. In these studies particular emphasis was placed upon the means of its spread within a single tree, from tree to tree, and from orchard to orchard.

EPIPHYTOLOGICAL STUDIES

The epiphytotic studies in relation to the spread of *P. pruni* and the disease were carried out over a period extending from the spring of 1938 to late autumn of 1940 in orchards located at Irvington, Illinois. These orchards were selected because of their favorable arrangement. Orchard A was planted to Elberta in 1935 and afforded a good supply of inoculum. Orchard B and C being planted to Elberta during

the winter and spring of 1938-1939 afforded disease free trees, assuming that the disease is not brought in on young trees from the nursery. Each orchard was examined periodically for spring cankers, primary foliage infection, and secondary foliage infection. A study was also made on the spread of the causal organism within a tree, from tree to tree, and from orchard to orchard. The purpose of these studies was to secure information on the factors which favor the dissemination of the organism and the development of the disease under orchard conditions.

Observations During 1939

Bacterial spot was moderate in its severity during 1939 but, nevertheless, every tree in Orchard A showed bacterial spot infection on July 18, 1939. Spring cankers were found but no attempt was made to determine the spread of the organism in this orchard. However, the spread of the organism from Orchard A to the young plantings in Orchards B and C was carefully studied.

Orchard B consisted of 569 trees planted in the fall of 1938. In the spring of 1939 a search for spring cankers in this orchard proved unsuccessful. Nevertheless, foliage infection was found on 68 trees at the end of the growing season. The position and relative severity of the disease in Orchard B clearly suggested that the inoculum originated in Orchard A.

Orchard C included 578 trees which were likewise planted in the fall of 1938. One spring canker was found in this orchard. The relation of the foliage infection to the canker was evident, for the canker occurred at the apex of a conical region of infection in the tree. On October 13, 1939, just previous to leaf fall, foliage infection was found on only 3 trees in this orchard.

Observations During 1940

During 1940 the orchards were examined at more frequent intervals than during 1939. In adidtion to the orchards surveyed during 1939 Orchard D was added to the studies.

This orchard was planted to Elberta, Hale, and Gage varieties in the fall of 1938.

In Orchard B 31 spring cankers were observed on 21 trees. Fifteen of the 21 diseased trees had been severely infected with bacterial spot during the previous season. The spread of the organism from the initial infection to adjacent trees was rather closely correlated with the direction of the wind. At the time of leaf fall every tree in this orchard showed bacterial spot in varying degrees of severity. In every case where a spring canker was present, the foliage below was found to be infected, and this infection invariably developed in a sort of cone with the canker at the apex.

In Orchard C spring cankers were observed on 3 trees, 2 of which had been severely infected during the 1939 season. In 1940 17 spring cankers were found on these 3 trees. On 1 tree 15 cankers were found. This case was unusual, since with this exception the largest number of spring cankers ever found on a single tree was 4. This was the only tree in this orchard upon which a spring canker was found during the 1939 season. As a rule only a single spring canker was found on a tree. At the time of the last examination of the trees foliage infection was found on 387 of the 578 trees.

In Orchard D 23 spring cankers were found on 19 trees. Foliage infection was found on 1169 trees. The addition of Orchard D permitted a study of the spread of the organism to the north and east of the old orchard.

As a result of these studies it may be assumed that climatic factors play an important part in determining the severity of the disease. The most important factor affecting the development and spread of the pathogen is moisture. Nevertheless, other factors must be taken into consideration as to the way in which they may influence the activity of the causal organism. Shading, direction and velocity of the wind, and heavy dews affect the rate of dissemination and extent of development. Results obtained in these studies further aid in substantiating earlier investigations.

Origin of Primary Inoculum

The source of the inoculum which causes primary foliage infection has been a matter of dispute. Various investigators have suggested such sources for this inoculum as overwintered summer cankers, diseased buds, fallen leaves, and spring cankers. Uncertainty existed in regard to whether the inoculum is present on the trees internally or externally during the dormant season or whether it is to be found elsewhere.

Overwintered Summer Cankers.—Dunegan[1] and others have postulated the possibility of *P. pruni* overwintering in cankers on the twigs of peach. These cankers which develop on the current year's growth have been subjected to critical study in Illinois. In no instance has it been found that *P. pruni* lives over in these cankerous regions. During the present studies many summer cankers were marked during their development and later collected and cultured at various times throughout the winter to determine whether or not the pathogen could survive the winter in these lesions. Since none of these cankers yielded *P. pruni* after December, it seems reasonable to assume that the organism is unable to survive in such cankers in Illinois.

Diseased Buds.—Several hundred terminal and lateral buds were cultured during the winter of 1938-39 and 1939-40 to determine whether or not they harbored the bacteria during the winter. These buds were taken from Elberta trees heavily infected during the summer. In no instance was *P. pruni* isolated from the buds after January. Nevertheless, in Delaware[2] it has been demonstrated that *P. pruni* becomes well established in the buds in August and is prevalent throughout the winter. As a result of these studies in Illinois it can be definitely stated that *P. pruni* does not spend the winter in the bud proper in this region. This is further substantiated by the data obtained

1. Dunegan, J. C. 1932. The bacterial spot of peach and other stone fruits. U. S. Dept. Agr. Tech. Bul. No. 273.
2. Manns, T. F., J. W. Heuberger, and S. L. Hopperstead. 1938 Bacterial spot of stone fruits. Del. Agr. Expt. Sta. Bul. 214. (Ann. Rpt. 1938) 37-39.

by Anderson[3] who reported attempted isolations from several hundred buds.

Fallen Leaves.—There may be a possibility of the bacteria overwintering in fallen leaves especially during mild winters. However, the amount of inoculum which is present in fallen leaves during early spring is usually negligible. The only satisfactory explanation of the manner in which the bacteria may reach the host is by splashing during periods of rain. This is not sufficient to explain the serious outbreaks of the disease.

Spring Cankers.—The most logical explanation of the origin of the inoculum for primary foliage infection in Illinois is spring cankers which are found on young succulent tissue of the past year's growth. However, as yet no satisfactory explanation as to where the bacteria overwinter prior to the formation of these cankers has been given.

During the past winter evidence was found which indicates that the primary inoculum is present within the twigs. With the hope of revealing the mode of overwintering of the bacteria, twigs were collected from trees of known susceptibility to the disease at various times during the dormant season and brought to the laboratory in order to break their dormancy. Twigs which had been placed in a moist chamber in a jar of warm water and subjected to artificial illumination presented ideal conditions for the rapid reproduction of any bacteria present within the twigs. Observations were made periodically to determine whether or not spring cankers developed on these twigs. Positive results were obtained for the first time on February 12, 1941 at which time incipient cankers were found on three Chinese seedling twigs from the collection made February 6, 1941. A total of 16 cankers developed on 183 twigs up to April 1, 1941. That these cankers were formed by *P. pruni* was proved by inoculating pure cultures secured from these cankers into peach trees growing in the greenhouse. These observations on the development of spring cankers on

3. Anderson, H. W. 1938. Recent advances in our knowledge of bacterial spot of peach. Ill. State Hort. Soc. Vol. 72: 479-487.

twigs, brought into the laboratory before breaking of dormancy outside, proves beyond question that these cankers must arise from infections of the previous season.

Two explanations may be suggested as to the mode of entrance of the bacteria into the twigs. First, it has been noticed that an increase in the activity of the bacteria occurs during the later part of the growing season. This is due to the return of conditions favorable for the development and dissemination of the organism. Frequently one can find late infections on the petioles of the leaves. It appears possible for rain and dew to wash the bacteria down the sides of the petioles and thus afford them opportunity to enter the cortex of the stem at the base of the petioles. This entrance might easily take place just before the completion of the abscission layer and the formation of the suberized cells which cover the leaf scars. The bacteria could then spend the dormant season within the cortex of the leaf gaps or in the cortex of the stem proper. Secondly, it also appears possible for the bacteria to move through the intercellular spaces of the mesophyll tissue of the leaves and pass through the cortex of the petiole into the cortex of the stem. These are only suggestions but, nevertheless, cases have been found which clearly suggest the possibility of either one of them being true.

THE RELATIONSHIP OF CHEMICAL CONSTITUENTS OF BARK TISSUE TO THE INITIAL INFECTIONS

Observations during the past three years have revealed that bacterial spot develops at an earlier date on Chinese seedlings than on standard varieties of peach. As a rule, spring cankers are also more numerous and the disease is considerably more severe in these Chinese seedlings. Because of the luxuriant twig growth produced yearly by Chinese seedlings it was assumed that this succulent tissue rendered the trees more susceptible to bacterial invasion. The purpose of these investigations was to determine whether the carbohydrate and nitrogen content of the bark of peach twigs may be correlated with the development of spring cankers.

Chemical analyses of the bark of Chinese seedlings and Elberta peach trees suggest the possibility that reducing sugars in the bark tissues appear to have more influence than non-reducing sugars and nitrogen on the development of spring cankers.

There is a gradual increase in reducing sugars during the winter months especially in the highly susceptible Chinese seedlings which reaches a maximum about the time spring canker development appears to be initiated. It would seem therefore that this might account in part for the extremely rapid development of the bacterial invasion of the bark in early spring, resulting in extensive cankered areas, and subsequent splitting of the bark along these areas. With the reduction in reducing sugars resulting from the demand of the developing foliage there is a cessation of bacterial invasion in the bark.

Nitrogen determinations of the bark were comparable in the two test varieties; therefore it is assumed that nitrogen is not the determining factor in the development of the organism.

Temperature and moisture along with other factors must also be considered as having an influence on the development of spring cankers. Since both Elberta and Chinese seedlings were growing in the same orchard under similar environmental conditions, one is justified in assuming that while these factors play an important part they are apparently not the determining factor in the development of spring cankers.

VITA

Howard William Larsh was born May 20, 1914 in E. St. Louis, Illinois. He attended the public schools of that city and was graduated from High School in June, 1932. In September of 1932 he entered McKendree College of Lebanon, Illinois, and was granted the degree of Bachelor of Arts upon graduation in June, 1936.

In the fall of 1936 he enrolled at Washington University of St. Louis, Missouri for his first year of graduate study. He matriculated at the University of Illinois in September, 1937, receiving the degree of Master of Science the following June. He served as graduate assistant in botany at Illinois from February, 1938 until June, 1941.

He was married to Miss Georgia Lee Thomson of St. Louis, Missouri on September 4, 1938, and has since made his home in Champaign, Illinois.

He is a member of Sigma Xi, Phi Sigma, Botanical Society of America, American Phytopathological Society, American Association for the Advancement of Science, and the Illinois Academy of Science.

He has published:

The Relative Prevalence of *Diplodia zeae* and *Diplodia macrospora* on Corn. Plant Disease Reporter Vol. 22: 159-163 Number 9, May 15, 1938.

Carbohydrate Utilization By *Diplodia macrospora*. Neil E. Stevens and Howard W. Larsh. Trans. Illinois Academy of Science, Volume 32, No. 2 (December, 1939).